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TECHNOLOGY ASSESSMENT IN DEVELOPING NATIONS: EMPHASIS ON SOLAR TECHNOLOGIES

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INTRODUCTION

This paper has been prepared for delivery in a United Nations workshop in Bangalore, India, between October 30 and November 10, 1978. It is organized around three topics: Technology Assessment (TA), Solar Energy (SE), and Developing Nations (DNs). The conference is devoted to the first and last; the author's expertise is primarily in the first two. Accordingly, the paper will attempt to use solar energy as an example of an emerging technology, the assessment of which should currently be of importance to developing nations. However, the specific technologies known as "solar energy" have interesting parallels to both technology assessment and developing nations through their (sometimes) pseudonym: "appropriate technology" (AT). This philosophical interplay will be further explored in the final section of this paper.

Since this paper is also intended to introduce the author to the other participants to the Bangalore conference, the brief chronology of Appendix A may explain the origin of the author's perceptions on the subject matter of this paper.

TECHNOLOGY ASSESSMENT

To this author, there are four fundamental components of a technology assessment (policies, impacts, actors, technology characterizations) as shown in Figure 1. Needless to say, however, there are many other aspects to a TA; one catalog of such a list is shown in Figure 2.[1] These will be discussed sequentially later, but should be referred to now to see the important elements of a TA which are not contained in Figure 1.

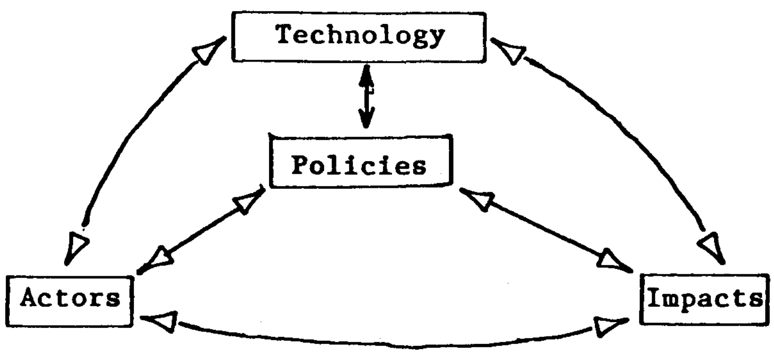

Figure 1 - Basics of a Technology Assessment

The central position of "policies" in Figure 1 is intentional. The difficulty of this aspect of a technology assessment, as well as the need to understand all the other aspects before developing policy options, has often led to the virtual ignoring of this topic. This can best be prevented by a close alliance between assessors and decision makers. It is critical that the assessment be done at the request of the decision makers and be timely--neither too soon nor too late in the policy process. In the author's opinion, however, it is inappropriate for policy makers to be closely linked to the actual conduct of the assessment; the policy maker can too easily arrive at the premature decision which a TA is designed to avoid.

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Figure 2. Outline of Forthcoming Technology Assessment Handbook (Reference 1)

Secondly, the assessment process must contain a full understanding of the technology. Unfortunately, TAs have often failed to go much beyond this necessary first step. To expedite this process, it is critical that the boundaries of the technology (time frame, number of competing technologies, projections of future conditions, etc.) be limited early in the process. On the other hand, it is equally important to cover the full range of realistic alternatives.

Thirdly, in any technology assessment, it is necessary to list and understand the perceptions of the various parties at interest to a new technology. One promising approach is to attempt to understand the links among obvious participants and all those with whom those participants are in regular contact. Of special importance is an understanding of the cause of potential opposition.

Lastly, the full analysis of the unexpected impacts which could accompany a new technology is the critical difference between a technology assessment and usual policy studies. However, although such an analysis is commendable, it is not obvious that any TA has initiated actions which have successfully averted such a secondary, unexpected impact. In part, this is because it is often difficult to separate primary from secondary impacts. What is secondary to one interest group can be of primary interest to another (e.g., environment or labor impacts). On the other hand, such an attempt can well lead to at least the full descriptions of impacts which are of primary interest to an important group.

Figure 2 identifies additional aspects of a TA that must be considered. The first three chapters in this list establish the rationale for TAs--perhaps the subject also of this workshop. In the author's opinion, both the need and value of a TA have been established; the methodologies are still in need of improvement. The basic features of Chapter 4 have been described above. Chapter 5 emphasizes the fact that each assessment must be handled uniquely; it remains more of an art than a science.

Chapters 6 and 7 deal with the description of the present state and forecasting of future states of both the technology and society under study. "Technology forecasting" is an art, often, unfortunately, also known by the term "technology assessment." The use of expert opinion with judicious use of parametric representation of the most important and least well understood variables are the keys to appropriate handling of forecasting. The description of present society is often ignored (though description of the technology never is); even less well done is the forecasting of a future state of society. Needless to say, this is a most difficult task, especially with developing nations.

Chapters 8 through 15 have (all too briefly) been discussed above. Note the separate emphases on identification, analysis, and evaluation of (a wide range of) impacts. The first is necessary to be sure that important, nonobvious impacts are surfaced. The use of all-encompassing lists and discussions with potentially impacted parties seems to be the best way to identify impacts. Initial decisions to eliminate the mundane are important, since many more can be identified than can be analyzed. Evaluation of impacts can only follow analysis and is rarely accomplished. The strong positive impacts (e.g., in environmental or labor categories) must be compared to strong negative impacts (e.g., in economic or cultural areas); this evaluation process necessitates a statement of the tradeoff of values which is both distasteful and important to the decision makers. As noted by Hazel Henderson,[2] OTA advisory council member:

> The evolving concepts and methodologies of technology assessment seem to be polarizing around two conflicting philosophies: (1) technology assessment should develop as an essentially "value-free" scientific discipline and (2) technology assessment is a normative process which must be recognized as rooted in and responsive to the dynamically changing values of the society on whose behalf it is conducted.

The author identifies himself firmly with the second viewpoint.

The policy identification and analysis process must follow the same path; these activities must meet the needs of the decision makers and must not arrive at the decisions which are the purview of the decision makers. Nevertheless, important conclusions cannot be held back either; it is a tricky, perhaps impossible, position for the assessor.

Communication of results (Chapter 16) is as important as the process of obtaining results. Most successful TAs have solved this problem by continued iteration and the use of communication experts.

Project management (Chapter 17) is an obvious, yet difficult and crucial, part of a successful TA. The difficulty stems, in part, from the interdisciplinary character of a TA, but also from its often sensitive political nature, the conflict of values, the urgency of the report, and the chronic shortage of funds.

Lastly, it would behoove both the assessors and the decision makers to build in an evaluation process (Chapter 18)--both before the TA's final delivery and for use in monitoring results after any actual decision.

Critiques of TA (Chapter 19) are often appropriately negative. Many types of failures have been identified above; they are not surprising since the TA process is both new and hugely difficult. Nevertheless, the future prospect (Chapter 20) for TA seems, to the author, to be bright. The primary reason for this statement is the danger inherent in not engaging in this or a similar process. However, the TA process may be less important for developing nations, because of the lack of development funds, the need for great caution in expenditure of the limited public funds, and the greater need to actually solve pressing human problems. On the other hand, certain technologies (including solar energy technologies), may be more attractive in developed nations, and the need for TA can therefore be more urgent.

SOLAR ENERGY

Solar energy is chosen for discussion here primarily because of the author's background. Nevertheless, it has been subjected to substantial technology assessment and it seems to offer significant potential for both benefits and disaster in developing nations. To make the points related to TA and DNs which are the main topics of this conference, it is necessary to give a brief description of the various solar technologies--virtually all of which should have some potential applicability to developing nations. In these discussions, the four primary TA components are identified where appropriate. To accomplish this brief overview, we shall briefly describe each of the chapter contents in an Annual Review of Solar Energy[3] in which the author is currently involved. Figure 3 contains the issues from three of the chapters; these issues are mainly of the type to be answered in a TA, but they also indirectly describe the present status of solar energy progress in the United States at this date.

Figure 4 presents these topics in a graphical form to show the relationships among the topics--much as in Figure 1. The first chapter identifies major recent solar activities. For the United States the two major ones are: Sun Day (held on May 3, 1978) a national citizen's celebration of solar energy; and a solar domestic policy review (DPR), which is the highest level U.S. federal solar discussion yet to take place. The latter had some of the characteristics of a TA (one major group studied impacts), but clearly was not. A second major activity of the DPR concerned the international implications of the U.S. solar policy. The following is a brief excerpt from the international section of the first DPR public report,[4] showing the perceptions of U.S. assessors about LDCs:

> An area of increasing interest is the international commercialization of solar technologies. DOE is beginning to investigate the overseas market potential and its possible domestic implications. The Department of Commerce, in cooperation with the commercial services of the United States Foreign Service, is increasing its information gathering activities on international solar markets and is beginning to sponsor solar trade fairs and ovesrseas exhibits of United States solar technologies. The Department of Treasury is also beginning to look into international solar programs.
>
> AID's programs in energy and technology transfer indicate a significant potential for the use of solar energy to supplement in the developing countries and that the basic problems facing the wider use of solar energy are institutional as well as economic--problems of financing, lack of an entrepreneurial base, issues of solar organization and governmental policies.

The first seven chapters in Part I of Figure 4 cover two of the four main topics of TA shown in Figure 1: Policies ("Choices" in Chapters 2 and 3) and Impacts. The major solar choices in the U.S. at this time seem to the author to be those of degree of urgency (Chapter 2) and type of solar technology to be deployed (centralized or decentralized) (Chapter 3). An important contribution to TA methodology (which indirectly relates to these two major choices) was provided in an early solar energy TA.[5] This was a presentation (a portion of which is shown in Figure 5) of three viewpoints on solar energy type and urgency by three hypothetical groups whose range of values covers much of the U.S. public. Other differentiating characteristics in the original were economic growth, regulation, decentralization (see below), goals and decision making; only the "world responsibility" characteristic is shown in Figure 5. A similar range of opinions or basic values presumably exists in every developing nation. A presentation of a similar three-by-three character

Chapter 3. The Federal Solar Program: From Research to Commercialization 1. Should greater emphasis be placed on decentralization (of ownership, etc)?

2. Should greater emphasis be placed on basic research?

3. Should greater emphasis be placed on commercialization?

   a. Are any technologies being held back?

   b. Is it cheaper to use the market place rather than to fund R&D?

4. Should greater emphasis be on the near-term solar technologies at the expense of the long-term?

5. Should any new program area be initiated or greatly expanded (desalinization, salinity gradients, SSPS, waves, etc)?

Chapter 27. International 1. Should the United States emphasize the export potential of solar energy by identifying markets? Conversely, should the United States emphasize the potential for developing solar energy within LDC's?

2. Should international cooperative efforts in solar RD&D be expanded?

   a. Are we sufficiently cognizant of work elsewhere (including tech transfer, incentives, etc.)?

3. Should U.S. solar development be expanded because of favorable foreign policy implications (nonproliferation, lessened oil demand, etc.)?

Chapter 34. Solar Thermal--Small Systems 1. Should greater emphasis be placed on small solar thermal power systems?

   a. Are the cost and market projection goals reasonable?

   b. What is the market at various size ranges?

   c. Is irrigation a viable long-term market?

2. Should greater emphasis be placed on utility or nonutility applications?

3. Should primary emphasis be placed on cogeneration or total energy?

   a. Are synergisms being adequately exploited?

Figure 3 Representative Issues from Reference 3 .

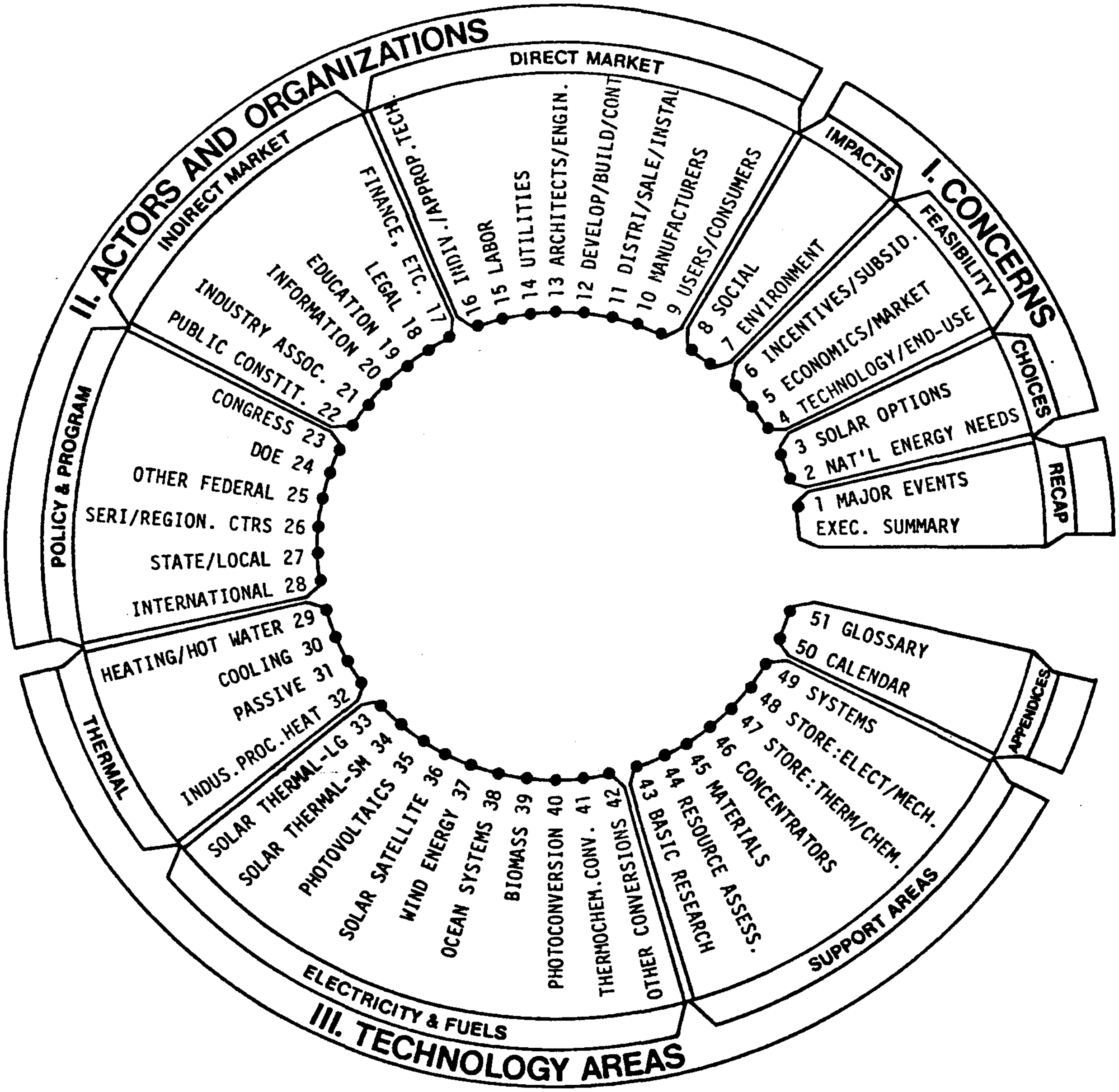

Figure 4 Schematic Diagram of Annual Review of Solar Energy: Volume 2

By persons whose own view is that of	Impression of		
	Perception A	Perception B	Perception C
Perception A	Right on!	Idealistic, impractical	Dangerous, revolutionary
Perception B	Irresponsible	Right on!	In the right direction but too radical—more gradual, rational approach is better
Perception C	Dangerous, dinosaur-like	In the right direction, but unrealistic about the extent of fundamental institutional change required	Right on!

CHARACTERISTICS OF PERCEPTION A

World Responsibility. The benefits of a high-growth, high-technology, free-enterprise society as compared with any feasible alternative are obvious and generally agreed to. Such a society provides the best hope for raising the nation's poor, and the poor of the world, to a higher state of material and social well-being. Hence a U.S. responsibility with regard to the world is to maintain its technological and economic leadership, and to aid poorer nations to industrialize and modernize.

CHARACTERISTICS OF PERCEPTION B

World Responsibility. A "fairness revolution" is necessary; the rich nations consume far more than their share of the Earth's limited resources and contribute far more than their share of environmental damage. The insistence of the poorer nations on a "new international economic order" is justified; a new order is essential to any hope of eventual world political stability. Richer nations like the U.S. need to consume less, support the redistribution of resources, and recognize the validity of societal choices other than Western style industrialization and agribusiness.

CHARACTERISTICS OF PERCEPTION C

World Responsibility. A "fairness revolution" in the world is necessary; however, this cannot come about without fundamental change in the nature of modern society. The basic paradigm of industrial society contains the seeds of international confrontation over finite planetary resources. It contains no rationale or incentive for planetary stewardship or for more equitable distribution of the Earth's resources. The industrialization trend and the goal of material progress, in the absence of more transcendental values, lead ineluctably to problems of resource depletion, environmental deterioration, hazardous substances, threats to the planet's life-support system, and international competition for the means to survive. Thus the desirable goals of Perception B cannot be achieved without a fundamental transformation of industrial society and its institutions.

Figure 5 Comparison of Three "Gestalts"

character is shown in Figure 6 with axes of urgency and type; it is not to be confused with the dimensions of Figure 4, but contains much of the information therein. In the author's mind, understanding values is at the center of every TA and should be a major focus of this workshop, as noted earlier in the brief excerpt from Reference 2.

		Requirement for Federal Urgency		
		None	Medium	Great
Type of Solar System	Centralized	A		
	Combined			B
	Decentralized	C		

Figure 6. Two Fundamental Value Choices in the Present U.S. National Solar Program Decisions Process (Definitions of A, B, and C are given in Figure 5.

Chapters 4-6 discuss three feasibility topics. First are issues related to the technical feasibility of 100% solar energy utilization. A recent Department of Energy study of the possible utilization of solar energy in the State of California, [6] which had some of the features of a TA, concluded that complete reliance was technically feasible. The major difficulty was determined to be in the area of solar-derived liquid fuels for transportation. This feasibility issue is still being pursued in several other such U.S. studies.

The economics of solar energy (Chapter 5) remains the central concern for most solar assessors as they indirectly address these dual issues of urgency and type of solar energy. The economics must, of course, be addressed in terms of life-cycle costs; first solar costs are still typically higher than the alternatives. However, for developing nations, the economics of solar energy will differ--primarily because the labor costs are lower, but also because indigenous materials must be used to keep the cost realistic. A second tradeoff will presumably favor higher maintenance costs over high first costs. Of critical importance in this computation is the assumed discount rate. The U.S. Department of Defense has recently been mandated by the U.S. Congress to use a zero-percent discount rate for solar life-cycle cost accounting. DOD is also making relatively high assumptions about future energy prices--it is not simply ignoring inflation. Lastly, it is reported to be attempting to include such social costs as the difference in impacts on unemployment, inflation, the environment and other impact categories. This may be the beginning of a much different form of U.S. national accounting, one that could have profound impact for both technology assessment and developing nations. Prior to this, the standard Federal discount rate was 10%; neither inflation nor social costs has been regularly included.

The sixth chapter discusses barriers, subsidies, and incentives--a return to policy options (Part 1 of Figure 1), but of a more technical type. This is an answer of how best to accomplish a goal, rather than whether that goal is worthwhile. The need to iterate a TA is most apparent here; the impacts of a policy may be as critical as the impacts of the technology it is designed to support.

The seventh and eighth chapters on environmental and social impacts are more grossly divided at this time than in many TAs because of the relative sparsity of new material. Of some surprise, and therefore of prime importance in Chapter 8, is the current rapidly increasing interest in solar energy in the U.S. on the part of religious and political establishments. The former is, in great part, driven by ethical concerns, including international equity.

The second major grouping is that of solar "actors" and organizations--much as shown in Figure 1. This could be used as a beginning checklist (a technique the author finds indispensable in any TA), even though the list will probably be greatly different in a developing nation.
With an abundance of solar technologies under discussion, the users (Chapter 9) will have to be much more finely divided than indicated here. Space does not permit more than a brief mention of the other important solar actors in the U.S.--labor, utilities, assessors, lenders, public interest organizations, etc. The full list of issues shown in Figure 3 for the international chapter gives an indication of how "actors" influence major U.S. solar issues.

Lastly, we turn to the technologies themselves. In the U.S., only the solar heating (including hot water) industry can now be said to be "mature," although the photovoltaics industry is rapidly approaching that state and the wind generator industry is making a rapid comeback to the position of strength held in the 1920s and 1930s. Even in these "mature" areas, a wide range of basic issues needs to be addressed--from simple categories such as whether to use air or water as the collection medium, to whether to use flat plates, concentrators, total energy systems, stand-alone or utility grid connection. The list of issues (a portion of which is shown in Figure 3) is intended as a directory of the major unsettled solar issues, the assessment of which will be a continuing process. Some have been partially assessed, but solar TA activity is by no means complete in the U.S.

This rapid review of solar energy from a TA perspective shows only too clearly the importance of adequate assessment. The list of unresolved issues is large, not only because the field is large and rapidly developing, but also because adequate assessment has not yet occurred. For developing nations, the solar energy assessment task is even more difficult since there are insufficient funds for false starts--either in choosing the wrong solar technology or in choosing between a solar and nonsolar option. From the perspective of the United States, the developing nations appear to offer a unique opportunity for mutally beneficial cooperative effort. This should only be undertaken after a full TA; some aspects of such a TA in a developing nation are contained in the next section.

THE TECHNOLOGY ASSESSMENT OF SOLAR ENERGY IN DEVELOPING NATIONS

The basic reason for believing that developing nations are an important area for a solar technology assessment arises from the present economic dilemma of solar devices: solar energy implementation can only advance with lower costs. However, the lower costs will only follow from much more intense implementation; hence, we have a classic chicken-and-egg situation. In the U.S., conventional energy costs are lower than in virtually any other country, so the domestic market for new solar devices appears bleak at this time. This is not so in many developing nations where conventional energy costs today are often ten times their U.S. values. Thus, U.S. manufacturers and policy analysts alike have recently begun to ask whether a synergism could develop and indeed, how it should be valued by each party.

If energy costs are lowered in a developing nation through the use of U.S.-supplied solar hardware, the resulting savings barely show up in the U.S. financial accounts, where it is our own imports of oil that are crucial. This is even more true if the solar units are primarily constructed in factories within the developing nation (which is clearly in the best interests of the developing nation). However, from the U.S. manufacturer's perspective, the solar sales are still important both in their own right and in the resultant learning which should enable costs to decline. From our national viewpoint such cost decreases are invaluable as they lead to increased production without Federal expense. Of perhaps even greater importance to the U.S. in the near-term are benefits of good will in our foreign affairs, congruity with our nuclear nonproliferation policy, and reduced pressures on the international oil supply.

Concerning the longer term, present U.S. energy dialogue is increasingly focusing on the problems of carbon dioxide buildup in the atmosphere. As our understanding of the impacts of a doubling in CO_2 content improves, it seems clear to this author that mammouth pressures will build for a cessation of fossil fuel combustion even assuming an abundant supply (which may not exist). Nuclear fission energy certainly, then, looks more attractive, but only with a breeder technology, since the supply of uranium now appears to be severely limited. To this author, the breeder issue appears to be political, not technological; widespread public uneasiness over a plutonium economy appears to be growing. Since fusion energy's economic (much less technological) success can hardly be assumed by any nation today, it would seem that, for most developing nations, the choice will come down, in the long term, to a future breeder or a future solar energy economy.

For the developing nations, this will often further evolve to a choice between building a national electrical grid in addition to the generating facilities or in having a decentralized system. In the U.S., transmission and distribution costs have been two to three times generation costs. Although basic transmission and distribution systems are in place, they are now a major headache for utility planners as citizens increasingly react against the condemnation procedures which precede their expansion.

However, to compound the problem for the assessors of solar energy in a developing nation, solar energy costs are themselves high, and solar products are generally not yet reliable. The issue then is one of forecasting solar costs and performance at that point when a breeder reactor could first be operational. An interim strategy using small, decentralized fossil-fuel-fired generators which could be converted to backup for future solar systems may be an optimal choice. Its primary competitor could well be the use of a modest storage system which is charged by a solar system. This set of choices seems to be the major energy issue to which solar energy TAs in developing nations will have to address themselves. The choice should be as difficult in a developing nation as in the U.S., which has certainly not yet made a national decision.

To conduct such a TA in a developing nation, several further considerations are obvious. The end-use requirements for the energy are foremost--it makes little sense to use electricity to heat water, for example. Liquid fuels for the transportation sector may be the critical choice; the U.S. has not begun to fully address meeting this need from renewable resources, except for a growing interest in gasohol (from both methanol and ethanol) and electric vehicles with electricity from solar generators.

A second major concern must be the special resources of each specific nation. Those with hydropower may be the most fortunate, others may have a wind resource, still others exceptionally good solar insolation. No single answer will work for every developing nation. The human resource cannot be overemphasized for developing nations. If unemployment or under-employment is serious, then a labor-intensive technology may be ideal.

Even more critical seems to be the need to foster energy technologies which minimize a currency drain. The use of indigenous materials and manufacturing facilities will, because of the multiplier effect, lead to a much larger impact on the local economy than the expenditures on solar energy alone. Developed nations with advanced solar technologies obviously see the developing nations as a potential export market today (see Figure 3). Nevertheless, U.S. solar energy planners are well aware of the transient nature of this market, as even the most sophisticated solar device can be readily manufactured anywhere. Overseas licensing of solar technologies appears to be expected.

Obvious positive features of increased availability of energy (of any kind) occur in the health sector, education, information, etc. A solar energy TA should explore whether any one form of energy generation is preferable to another. In the author's mind, the answer is probably no--rather, in these categories, it is primarily a matter of economics. However, as noted earlier, the economic computation for a technology assessment in a developing nation should be carefully considered; a decision on the appropriate discount rate and a careful definition of costs and benefits is a critical first step.

For many forms of solar technology, implementation may now be economic in a national sense even if not for a single entrepreneur. The developing nation problem is the financing of relatively low-cost components, for example fiberglass, whose payback against any other form of energy might be measured in months in certain developing nation situations, but still could be made obsolete by a later centralized form. On the negative side, each developing nation must also weigh the need for the capital for developing export market products. Access to low-cost energy might increase the exportable output from the most remote village, but the comparison will never be easy.

Considerable change in the local culture will undoubtedly result from improved access to energy of any kind. The relative position of the sexes could reverse as one or the other is relieved of a present burden or provided with a new source of power or prestige. Longevity increases may impose a still more serious burden as populations explode. Cultural taboos may oppose certain technologies (e.g., methane from human waste) but will certainly influence every outcome. A daytime cooking tradition in one country may allow a solar technology to thrive that could never be accepted in a country with night-time cooking. Lastly, interlocking or overlapping forms of government may thwart a technology which is threatening to any.

In summary, the decision to pursue a specific energy path in any developing nation should be preceded by at least a minimal TA. An energy success in one country need not imply success in another; TA is a potentially powerful approach to arriving at an optimal solution for nations in short supply of cash and time.

OTHER RELATIONSHIPS

The technology assessment movement began from a concern over the negative aspects of technologies. Although it has come to be known by some as technology harassment or arrestment, the assessment process has largely become a province of the technically trained individual among which the author includes himself. In frustration, some of those who share a concern over the path of present technology have taken an altogether different approach to solving the problem which they perceive. Their answer is most often known in the U.S. by the term "Appropriate Technology" or AT (which is an interesting permutation of the TA to which this paper has largely addressed itself). There is no pretense in the AT community of studying technologies to determine their character; rather, the "best" technology is understood--generally the least complicated. Although a single definition is hard to obtain, they generally have the characteristics ascribed to the decentralized solar technologies: they are easily understood, controlled, repaired, and fail in nonfatal fashion.

Two AT friends who recently returned from an AID-sponsored trip to investigate AT's potential in four Africa developing nations concluded at first (after not being able to repair a broken transistor radio) that there was little they could improve in the "appropriateness" of the technology of those nations. However, their skill in AT and knowledge of scientific principles make me believe they will have an impact on those nations, if they haven't already. Figure 7 shows a few of the impacts of various ATs in one of the countries they studied. In every sense, this was a TA of AT.[7]

RET Description / Identified Needs	"In Use"			Proven			Adaptive			Developmenta
	Shallow Well Wind Systems	Small Scale Hydro and Hydraulic Ram	Solar Hot Water	Solar Reliant Greenhouse	Passive Solar H/V/C	Solar Cell Communications	Solar Cookersdryers and Ovens	Improved Wood Stoves	Methane Digestors	Thatch/Cellulose Insulation
A. Domestic										
1)Thermal Energy Source			x	x	x		x	x	x	x
a)Cooking			x				x	x	x	
b)Heating			x	x	x				x	x
2)Improved Thermal Performance of Houses			x	x	x					x
3)Water	x	x		x					x	
a)Potable	x	x		x					x	
b)Agricultural	x	x		x					x	
4)Food Supply	x	x		x					x	
5)Communications-Radio						x				
6)Rural Electrification		x								
7)Human and Animal Waste Disposal									x	
8)Overburden Women	x		x	x	x				x	x
B. Agricultural									x	
1)Traction				x						
2)Animal Food Supply	x			x					x	
C. Socio/Economic				x	x	x	x	x	x	x
1)Rural Employment	x	x	x	x	x	x	x	x	x	x
2)Income Generation	x	x	x	x	x	x	x	x	x	x
3)Technically Trained People	x	x	x	x	x	x	x	x	x	x
D. Environmental									x	
1)Overgrazing				x					x	
2)Erosion										
3)Deforestation			x	x	x		x	x	x	

Figure 7. Technology--Needs Matrix for Lesotho (Reference 5)

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The point, then, is that TA and AT (including solar energy) are closely linked. It happens that in the U.S., AT and solar energy are virtually synonomous, but in every nation the technology assessment (TA) should identify the appropriate technology (AT). In some cases, the appropriate technology will be highly sophisticated; an example often used by Amory Lovins is the digital calculator.

For developing nations, TA may be foreign or even unnecessary since the prevailing technology is already "appropriate" and appropriate perturbations may be all which can or will be accepted in that country. It is the author's opinion and hope, however, that the use of TA is worth promoting and that TA can prevent some developing nations from pursuing paths which the developed nations are now beginning to leave.

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APPENDIX A

BIOGRAPHY OF AUTHOR RELATED TO TA, SE, AND DNs

1970-73 Professor of Electrical Engineering, Georgia Institute of Technology

1. TA - beginning interest; taught several courses in "technology and society"

2. SE - began interest in energy problems, little on SE

3. DN - acquaintance with students from DNs

1973-74 Staff, U.S. House of Representatives, Committee on Science and Astronautics

1. TA - staff to subcommittee which established OTA; also worked on science policy organization

2. SE - worked on first solar legislation to pass U.S. Congress

3. DN - virtually no contact

1974-75 Solar Project Leader, Office of Assessment (OTA), U.S. Congress

1. TA - participant in numerous discussions, conferences, etc., on procedures and importance of TA

2. SE - Program Manager of TA of "On-site Solar Energy," which is a small-scale, integrated approach to providing both electricity (through photovoltaics or solar thermal approaches) as well as thermal energy (through the "waste" heat)

3. DN - peripherally studied as a potential major actor in solar energy development

1975-77 Professor of Electrical Engineering, Georgia Institute of Technology

1. TA - worked as coauthor of book on TA used in course on TA which was taught three times; consultant to OTA

2. SE - taught several courses; faculty advisor for large student group building solar electricity devices for a national student competition (solar thermal electricity, photovoltaics, wind, methane digesters); consultant on several projects

3. DN - acquaintancy again with students; low-cost student project probably had much of the flavor of working in DNs (labor-intensive, use of local materials, etc.)

1977-78 Branch Chief, Program Evaluation, SERI

1. TA - job covers all aspects (i.e.,--a TA) of the present U.S. solar program; participant in national policy discussions

2. SE - knowledge as a reviewer, and evaluator of the U.S. national solar program; responsible for Annual Review of Solar Energy.

3. DN - interaction intermittently with international visitors; contacts with AT advocates knowledgeable about DN